sors are four-lobed, and that in the upper jaw one more premolar tooth is found inserted, of so small a size that it is difficult to discover its place, which is close to the canine tooth; in this respect it reminds one of *Molussus Australis* (Gray).

Should this species now before the Philosophical Institute be a previously undescribed one, allow me to name it after our respected President, *Vespertilio Muelleri*.

Melbourne, April 1859.

EXPLANATION OF PLATE.

Figures 1, 2, 3, natural size; 4, 5, 6, 7, 8, 9, 10, more or less magnified; Figure 10 represents the canine tooth and the two premolar teeth of the upper jaw, as seen from the inner side; the minute premolar tooth is also shown in Figure 8.

ART. V.—*Suggestions for a System of Drainage for Melbourne.* By the Hon. JOHN HOOD, M.L.C.

[Read before the Institute, June 1, 1859.]

MR. PRESIDENT AND GENTLEMEN:

I am not unaware of the amount of apology which should accompany a paper upon the Drainage of Towns submitted to the Institute by a non-professional. When I reflect that it numbers among its members many of our most eminent physicians and surgeons, I feel, indeed, that it is an act of rashness to venture on any remarks on the sanitary aspect of the question; recollecting, also, that many engineers of high standing and repute are even now present, some of whom have, in a special degree, made "Town Drainage" a subject of study, I am sensible, in touching upon their particular department of the question, that the fullest indulgence is necessary. Whilst, however, I apologise for my temerity in submitting my views on these heads, I may add, that on one other point on which I have chosen to express an opinion—the financial —I may, perhaps, without egotism, claim to be, at least, on a par with most members present. Nevertheless, I wish it to be distinctly understood, that even on this point I express my views with great diffidence; and that should they be shown to be incorrect throughout, I would, even then, not be disappointed. And if my failure shall have the effect of stimulating public opinion to immediate action, either through the

sole medium of this Society, or in conjunction with the press, so that the matter may receive that share of attention its importance pressingly demands, and so lead to a practical and useful result, I shall feel that my labor has not been in vain.

In most instances in which a preconceived idea of a large city has been carried out, it will be found that an adequate scheme for its drainage has been included; as, however, cities but rarely come into existence under such favorable circumstances, but rather grow up from a primary nucleus, a provisional foundation for the sanitary wants of the city in its ultimate growth and power will be usually wanting. From time to time wants of this nature will press themselves upon the public attention, and will be remedied, but generally, with only moderate foresight. The requirements of the future will be anticipated for only a short time, and at no more than the experienced rate of progress.

Melbourne must rank as a city that has grown, and, therefore, comes under the last-mentioned class; and this, notwithstanding the rapidity of its progress; for although a rectangular disposition of its streets would imply an original plan, this appears to be the whole that was pre-conceived, and little or no attention to levels or drainage has been hitherto given.

If we were to estimate the actual outlay by individuals consequent upon sickness, and the loss resulting from the suspension of their labors, and were to trace the connection between the sickness and the want of proper drainage in this large city, we should, probably, find the money value of the injury thus caused to be far greater than the whole sum required to provide it with efficient and durable sewers. The extravagance of this state of affairs can hardly be conceived; nor is it until statistics are combined with the observations of chemists and physicians that the public awake to a right appreciation of the evils endured. Hitherto experience has proved such to be the result in localities even more favorably situated than our own; and, doubtless, were the proper investigation attainable here, we should find *that* experience most emphatically confirmed. The other evils, resulting from uncleanliness and disease, I do not dwell upon; I content myself with pointing out to you that we are annually spending in palliatives more than would suffice to remove the cause. That fact alone should form an adequate apology for bringing the matter before this Society.

Mankind are apt to deem those wants more important that

are most imminent. On no other theory can I account for the expenditure so freely incurred to supply Melbourne and other cities with water, whilst drainage has been left almost totally unattended to. Our colony is not solitary in this display of energy in one essential, and apathy in another of equal ultimate moment. The London Board of Health noticed the like feeling at home. "Sometimes, indeed," say they, "women complain of the want of water or of its excess in lower apartments; but they appear to be unaware of the effects of filth and over-crowding as causes of mortal disease among their children."* Ignorance is in this, as in most matters, the great obstacle to improvement. There are some who say that we do not want drainage—some that it would be too costly for our means—whilst others pronounce it impossible. To the first, I would reply that the increasing foulness of the lower portions of the city, and the fœtid exhalations emitted from the cesspools, crowding its back courts and yards, are sufficient to prove the contrary. To the second, I might say that the preservation of health and the diminution of mortality are scarcely to be reckoned by the same tariff as a marketable commodity; but I shall, I trust, be able to show you, in detail, that there is no foundation for the assertion of difficulty upon the score of expense. And to the third, I may, in a general sense, allege, that where there is a well defined surface drainage, as in our own case, underground sewage, with the means placed by science at our disposal, is not impracticable. On all the points raised I shall endeavor to place before you, as succinctly as I can, such facts and inferences as will meet every objection; at the same time endeavoring to show the necessity and advantage of early operations, to obviate the dangers which our previous neglect has rendered imminent.

And, firstly, as to the want of drainage:

In densely populated cities, similar in situation to Melbourne, there is, necessarily, a considerable portion of animal impurity in the surface drainage. To this every house contributes from the culinary and cleansing operations of the day, if from no other cause. In the lower and most crowded classes of dwellings this will be the case, but in a more aggravated form. A comparison of the pale yellow-tinted surface-water running in the streets during heavy rain, with the dark colored and foul out-porings from the house-drains taking

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* Report from 1848 to 1854, published 1854; p. 36.

place at the same time, will sufficiently instance the amount of decaying matter contributed from the source mentioned.

Bad as the case thus appears, it will present itself in a far worse light when the cesspools that form adjuncts to every house in Melbourne are taken into consideration. What their effect must be may be easily estimated. On each side of Collins-street, for instance, at intervals of 20 feet, are not less than 200 heaps of the most offensive material, each measuring, say 25 cubic feet, constantly moist, and unintermittingly generating the most fœtid exhalations. These lines of pestilent matter are repeated in each of the main streets, and again by others on the numerous intersecting cross streets, and further increased in similar accumulations by the innumerable small courts and bye-ways. This offensive matter, it is true, is not in heaps above the surface, but in holes sunk in the ground—its moisture does not run into the channels—but it soaks into the soil, percolating into the cellars and foundations of houses, and the vapor given off, although diluted and disseminated by filtration through the soil, is just as dangerous as though it were generated above ground. People act as though they were scarcely aware of this circumstance, for they will protest most vigorously against a temporary deposit of mere rubbish in front of their dwellings, whilst they patiently bear the continuous existence of a filthy cesspool in their back-yard.

The baneful influence upon the health and longevity of the people, inevitably resulting from such causes, is too well-known to demand either explanation or comment upon the present occasion. The connection traced by common experience, between sickness and a foul atmosphere, indeed all the researches of science in reference to the cause and progress of miasma, have, over and over again, demonstrated this point with unerring precision. I content myself, therefore, by a mere allusion to the fact, but I would beg permission to enumerate the consequences—epidemic disease, fever, and that scourge of humanity, cholera—these have invariably followed like a shadow, wherever the necessity of drainage has been ignored; and to remind you that these evils are liable to become intensified here by our peculiarities of climate. Without further dwelling upon the necessity existing for drainage, I proceed to my second point :—

That drainage of an adequate description for the city of Melbourne is not too costly for the means at our disposal; in short, that we can afford it.

I premise, that by drainage I mean—firstly, drainage for the rainfall, involving some improvements upon the existing system—secondly, under-ground drainage for the sewage from cesspools, water closets, and other analogous sources of impurity. I say underground, for I cannot, for one moment, conceive any system of open drains at all suitable for sewage water. The rejection and universal condemnation of any such dangerous and miserable expedients by the highest authorities in Great Britain, render it unnecessary for me to do more than cite that fact in support of my position.

With respect to the surface drainage, considerable progress has already been made in constructing the necessary water-tables on the sides of the footpaths, but some errors appear to me to be included in the existing practice. In many cases drains from back-yards are allowed to run under the floors of houses into the street channels. These drains are very often most imperfectly formed, many of them consisting of mere flat stones or planking at the bottom, the sides being of brick about six inches in height, and the top of planking like the bottom. In such drains the water flows very slowly; accumulations of offensive matter are caused by the roughness and irregularity of the channel; rats destroy these drains of porous brick, allowing the escape of foul air into the houses, and, often, of the dirty water into the foundations. The result is, that the earth under the floors is kept in a moist and unhealthy state. In fact, it becomes saturated with filth, permanently exhaling an offensive odour into the house. I have known of loud complaints of this class of nuisance from residents in some of the best houses in Collins-street. No drains, therefore, should be allowed to pass under a house, unless constructed of perfectly impermeable materials. The kind best adapted for such purposes I shall have occasion to allude to presently. Another defect in the present method of surface drainage is the manner in which the crossings at the intersections of the streets are constructed, the water-tables of the leading channels being carried across the thoroughfares, as in Elizabeth and Swanston streets. The result of this arrangement is great inconvenience, both in the roadway and to foot passengers, an inconvenience that could easily be avoided. Take Collins-street and Elizabeth-street, for instance:—if cast-iron oval drain pipes, of moderate capacity, were laid along the water channel, commencing and terminating about 15 feet from the edge of the Collins-street kerb, the roadway could be

continued over these, and the foot communication rendered perfect, and yet the necessary water channel be preserved. Of course the communication with the channels down Collins-street would be by curved junction pipes of similar dimensions, commencing at another 15 feet from the angle of intersection of the kerbing. I am aware that covered drains have been tried before, but I am also aware that they were simply enlarged specimens of the defective construction of house drains already alluded to. When it is remembered that it has been proved by actual experiment that a three-inch pipe drain is more efficient than a nine-inch brick barrel drain, it will be probably conceded that the failure referred to affords no argument against the plan here suggested.

I now come to the great question, the sewerage of the city itself and the employment of a system of underground drainage for that purpose. My views may probably be met by a reference to the costly and complex systems that have been in operation at home; and it may be said that their failure should operate against the adoption of analogous schemes here. To this I reply, that we are not compelled to adopt their failures, but that we can benefit by their improvements; and, with your permission, I will now endeavor to show, as briefly as possible, the causes of those failures which we should avoid, and the nature of those improvements which it would be wise to adopt. I may, however, remark, that all the evils attributed to the old world system are not equal to a tithe of those that would have followed—and in all cases did follow—where drainage was altogether ignored.

One evil in the old system was the employment of sewers for carrying off surface water as well as house drainage. From this cause large quantities of silt found their way into the drains, gradually choking them up. In localities liable to sudden and frequent storms there existed the further objection that sewers adequate to the requirements of the ordinary drainage were burst by the rapid accumulation and consequent pressure of storm waters. Hence, in any efficient system, separate provision is requisite for surface drainage and for house sewerage.

But a greater and more prolific source of mischief in the old world system, as it existed about ten years since, was to be found in the *form* of the sewers, both large and small. The main sewers were generally of large size—five feet six inches high and three feet wide; the top arched over, the sides perpendicular, the bottom a portion of a very flat seg-

ment of a circle. The house drains were sometimes square, of bricks laid dry; sometimes of like shape, but formed of flat stones at top and bottom, and rough stonework at the sides; sometimes with straight sides and top, but triangular bottom; sometimes of brick, circular in shape, but roughly and carelessly formed. The fault incidental to all these last was, that not only were they larger than their purpose required, but that their size, by diminishing the force of the current, further lessened by the friction presented by their rude surfaces, diminished their utility. With such rough surfaces, the diameter could scarcely be reduced with safety, because of the readiness with which they then choked; and hence investigations were made as to the possibility of procuring more available channels less in size and smoother in their bore. But, before this was done, a series of investigations were made as to the condition of many of the leading lines of sewer, and some curious results, shown in the Reports of the London Board of Health, were arrived at.

Of these, allow me to enumerate the following:—

In the first instance it was discovered that very many of the existing sewers were generally, to an extent varying from one-half to three-fourths of their superficial area, filled with the deposit arising from the inefficient flow of the sewage in its passage through. The space left was ample for carrying away the ordinary drainage, but on the occurrence of heavy storms, stoppages and injury to the sewers took place. Hence, the conclusion that logically followed was that smaller drains would do if the escape of storm water was provided for on the surface. The baneful effect of these fœtid accumulations on the health of the districts where they prevailed, was the principal cause of these inquiries.*

Proceeding further in these inquiries, it was found that

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* For instance:—"A severe epidemic fever had burst out in the houses connected with the cloisters at Westminster. Thirty scholars and inmates had been attacked, of whom several died. The houses had nearly all cesspools, and the inmates, during the variations of the weather, were beset with foul smells. On examination it was found that beneath the houses in which the fever raged there was a network of cesspools, old drains and sewers. From beneath fifteen houses, which were the chief seats of fever, one hundred and fifty loads of ordure were taken; and from drains and cesspools connected with the houses, upwards of four hundred loads were taken. * * * The cesspool matter in one private sewer was nine feet deep. * * * These cesspools and old drains were all filled up, and an entire system of tubular house drains with water closets substituted." As a matter of course the health of the district was immediately improved, and the average of deaths fell from 30 to 17 in the 1000 per annum.

the only means of cleansing the smaller drains was by opening, and, in fact, partially reconstructing them. For the larger sewers there was no alternative but sending men to remove the filthy deposit. The many manifest objections to this mode of keeping a clear way, led to a trial of cleansing the large drains and tributaries by other means. The first that suggested itself was by "flushing." This plan was not found to be in all cases practicable; and, moreover, where it could be applied, the great size of many of the sewers, and the rapid accumulation of deposit in them, required a supply of water not always attainable. From these difficulties arose the trials which more immediately led to the introduction of the tubular system which now prevails so extensively.

These investigations resulted in the discovery that the force of a given body of water passing down a stated incline was in an almost inverse ratio to the surface presented for it to travel over, a fact which has been illustrated as follows:— "A stream four feet wide and one inch deep, with a fall of 1 in 150 is sluggish; the same water if passed through a pipe of twelve inches diameter, having the same rate of fall, would be, comparatively, a rapid stream. The one would deposit silt or sand, the other would certainly remove both." A sewer presenting the sectional shape of an egg was suggested as the most efficient for general purposes where considerable size was necessary, from combining in conformity with the above rule the greatest possible strength with the least obstruction to the passage of water. It was further shown, that while smoothness of surface and exactness of shape were essential, as presenting nothing for sullage to lay hold of, the preservation of or near approach to the circular shape was equally so, as admitting of a nearly equal pressure of fluid at all points. The delivering value of pipes of perfect outline and smooth surface was found to be at least 25 per cent. over slovenly made and irregular tubes, or, in other words, the flow of water through them was one-fourth faster. These experiments further showed that a pipe of three inches diameter, fifty feet long, and laid at a fall of 1 in 120, discharged one hundred gallons of water in three minutes, the water not being higher at its inlet than the head of the pipe; whilst a fifty feet length of pipe, six inches diameter, laid at an inclination of 1 in 100, discharged the same quantity of water in fifteen seconds. Other experiments on tubes of larger size gave correlative results.

The next point was comparison of tubular drains with the

sewers already in existence; and the trials instituted gave some extraordinary facts, one of which, and that by no means at variance with the general results, I proceed to quote:—

"The main line of sewer in Upper George-street is five feet six inches high, and three feet six inches wide, and runs from the Edgeware-road to Manchester-street, where it falls into the King's Scholars Pond sewer. I have laid a twelve inch pipe, five hundred and sixty feet long, upon the invert of this main line, and have built a head wall at the end of it, so that the whole of the sewage discharged by the collateral sewers above the pipe, as well as what sewage may find its way independently into the upper part of George-street, is forced to pass through the pipe.

"The whole area drained by the sewers running into the twelve inch pipe in George-street is 213,788 square yards, or about 44 acres. Observations are being continually made on the work, and the results are as follows:—'The velocity of the stream in the pipe has been observed to be four and a half times greater than the velocity of the same amount of water on the bed of the old sewer. The pipe has not been found to contain any deposit, but during heavy rains stones have been distinctly heard rattling through it. When the pipe is nearly filled, the velocity and concentration of the water are sufficient to clear away any matter which may have been drawn into it from the large sewers, and much of which matter, it may be presumed, would never enter a well-regulated system of pipe sewers; also, the force of the water issuing from the end of the pipe is sufficiently great to keep the bottom of the old sewer perfectly clean for twelve feet in length. * * * On the invert of the old sewer, which now forms the bed of the pipe, deposit was constantly accumulating, and was only partially kept under by repeated flushings.*'" I do not think it necessary to extend the quotation or to multiply instances.

A great number of trials were made in various localities, and always with similar results, and at length the requisites for the adequate drainage of any district was reduced primarily under three distinct heads, viz.:—

1. The quantity of sullage to be removed from any given area.
2. The rate of inclination obtainable.
3. The outlet.

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* Report Board of Health for 1852, p. 53.

These being ascertained, the size of the sewers became a mere matter of calculation. Undoubtedly in London, and in some of the larger towns, the passage of storm waters supplied another item for consideration. But, as before shown, surface drainage and house sewage should be kept distinct whenever this can be effected. In this country, where long dry seasons are succeeded by heavy storms, it would appear to me to be exceedingly absurd to attempt the combination of both in one system. But while the principal utility of such sudden irruptions of water is to "flush" the sewers; in our case we are rendered independent of this use of storm waters, by the command which we possess in the powerful and continuous supply of the Yan Yean. For these reasons, I would suggest that we may confine our attention to the three primary requirements as already stated.

Before, however, proceeding further, I may allude to the objections that have been made to the tubular system of drainage as compared with that by brick sewers, which may be thus stated:—*

1. Danger of breakage from weight of superincumbent earth, &c.

This objection is plausible, but unsound. Undoubtedly, when stoneware drain pipes are placed within six or twelve inches of a common road, damage may be reasonably expected, but in no instance has experience shown that such pipes, placed in similar situations to brick sewers and properly bedded, have failed to bear all the weight imposed upon them.

2. That the sedimentary deposit quickly becomes a complete plug.

To this it is replied that experience has demonstrated that, with the ordinary proportion of water in the sullage, when the pipes are properly laid, no deposit can or does take place.

3. The liability of stoppage from substances that would find their way in the larger channels.

This may be admitted, if it can be shown that large substances *can* find their way into small drains. With ordinary care, the admission of foreign matter can be prevented; and for the removal of all, except bodies as large as the drains

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* I acknowledge here the value of a very fair Summary in the Engineer's Pocket Book for 1858.

themselves, the rapid flow resulting from the smoothness and small diameter of the pipes is sufficient.

4. Facilities for malicious stoppage.

This objection equally applies to the ordinary water closet, which any spiteful servant can easily render useless; but it has not yet been argued that therefore water closets are inferior to the common privies and cesspools. And besides, it would not be easy to show wherein the presumed facility in this case consists.

There are other objections, principally based on the difficulty of getting at the point of obstruction whenever it occurs in these drains. At the first introduction of the system much difficulty did exist, as any one may easily conceive, who has seen our ordinary gas mains laid down, in which the removal of any pipe on the line is a matter of much trouble, and the efficient substitution of another not easily effected. But recent improvements in the junction of drain pipes have obviated the objection alluded to; a species of lid, with a flange, forming the top joint, and being easily removable without disturbing the main pipes. Hence, with manholes and pressure guages for examination at a few points, the locality of any obstruction is easily ascertained, and the obstacle as easily removed as in a brick sewer of large size.

The advantages of the tubular system may be thus summed up. It is very much less costly than brick sewers, for instance:—The town of Rugby was drained by pipes varying in diameter from six inches to twenty inches at a cost of £3,600, while brick sewers would have cost £15,000. Occupying less area in height, it admits of better fall, and by the acceleration and concentration of its flow secures both the rapid transmission of refuse and the diminution of stench. The impermeability of the pipes prevents the percolation of noxious matter into the adjacent soil. The tubular system is moreover impregnable to rats. In illustration of this point of advantage, I may refer to the large revenue said to be derived by the periodical sale of rat skins (after flushing) to the glove makers of Paris.

But whilst admitting the advantages of the tubular system, it should be borne in mind that, to secure all the desired benefits, it must be honestly and efficiently carried out. Most of the defects that have been urged against it as a system, have in reality arisen from bad workmanship. The others have been obviated by improvements of the system itself. Allow me to touch slightly upon this part of the sub-

ject before proceeding to those suggestions for the drainage of our own city, which appear to me to spring naturally from the data I have adduced.

I need scarcely say that the pipes must be of adequate thickness and strength, perfectly smooth in their bore, well covered by a thoroughly repellent glaze on their surfaces, and accurately jointed. The bed in which they are laid must be of uniform solidity, well rammed, and where necessary, concreted. The earth should be pressed round and above them in layers, so that the danger of disjointing from uneven bearing may be prevented. Taking a lesson from the circulating system in the human economy, the junctions of the pipes should be curved in such a manner as to blend the current without opposition; a junction at right angles being favorable to the accumulation of deposit. The stopping of the joints should be such as to prevent any internal obstructions, and proper traps should be provided at all inlets to prevent the admission of material for stoppage. Occasional flushing from the water mains should be secured as both promoting the cleansing and ventilation of the drains. The shortest distance practicable from the summit of any drain to its outfall should be sought for, but the fall should be the quickest in tributaries, as in house drains. Means of examination should be provided at intervals; and the execution of the drainage, and its supervision when completed, should be under competent engineers and workmen; in fact, none others should be allowed to interfere with either the plan or the construction. Without entering upon the subject of the ventilation of sewers, I may remark that provision for escape of noxious gases must be provided, otherwise they will force their way through the water in the traps, and become injurious in a very high degree. Doubtless, the best methods of encompassing many of these practical points are yet subjects for professional and scientific investigation. As a most important, although subsidiary accessary to any system of drainage, a proper water closet to each dwelling is indispensable. I do not mean the antique combination of pulleys, levers, and valves, so dear to plumbers and their customers, but the common syphon trap, stoneware pan, and bason, which at this time can be purchased in London for 7s. 6d., and is insisted upon by the authorities acting under the Board of Health throughout England.

Returning, to the topic of the cost of the drainage of Melbourne, I may state that on an average two miles of sewers

in provincial towns serve for the sewage of the habitations of about 1000 of the population. This is the result arrived at after some years experience and investigation by the London Board of Health. I assume that Melbourne and its suburbs will, to a great extent, come within the description referred to; and taking its population at about 75,000, the length of sewage to be provided would be about 150 miles. We have then to arrive at some conclusions as to its cost.

On referring to the table on the relative cost of supplying earthenware drain pipes, and laying the same complete, as given in the 179th page of the Report for 1852 of the London Board of Health, it is found that the average cost of pipes, and laying, in situations analagous in many respects to that of our own city—the depth being nine feet below the surface, and the diameter of the pipes varying from four inches to twenty-one inches—was 8s. per yard, or £700 per mile. Since that date, improvements have been made in the manufacture of the pipes, and the cost has also been reduced, but the alterations have involved a little more labor in laying, so that upon the whole the price may be fairly quoted as that which probably obtains at home now. In order that I may not be supposed to take too sanguine a view of the subject, I will assume the cost here to be four times that at home, which would bring the required outlay to £2800, but let us say £3000 per mile. The total outlay, then, for the sewage proper would be £450,000. As there would be other works in connection with the final outlet, I will suppose their cost to be £50,000, a sum much in excess of what would be required, and that the total outlay would be £500,000; I have then to show how that sum might be obtained, and how it would ultimately be paid off.

But before entering on this subject I may as well advert to one or two other points in connection with the tubular system. The first is a method of applying it, known as "back drainage," that is draining through back yards into lanes or bye-ways, in preference to carrying the drains under houses to main sewers in the streets. In many cases such a plan has a very great advantage, both in economy and efficiency, but it is not invariably applicable. One necessity to be kept in mind is that of avoiding frequent angles and turns in drains, and therefore where much intricacy occurs, as in intersecting courts and rights-of-way, back drainage is not equal to that which admits of straight lines direct from the point of inlet to the discharge into the sewer. This, however, does but

touch upon the application of the tubular system, and in this, the engineer must, of course, to a considerable extent, be guided by local circumstances. The question, in fact, is purely one of locality. The second refers to the preference sometimes given to two main pipes of relatively smaller size, one on each side of the street, over one large one in the centre. Viewed as a question of expense, there will probably be little difference; but regarded as a question of efficiency, the duplex arrangement may be preferable. The distance from the inlet to the main drain would be less, and the fall more rapid in the duplex system, advantages not to be overlooked.

The minor points being disposed of, allow me to revert to the main consideration:—the method by which the £500,000 required could be obtained. Any recourse to the general revenue I look upon as impolitic (although, in England, the general revenue is supplying the funds for London sewage), because the object of expenditure is in itself so purely local that it would be next to an impossibility to overcome the objection of the provinces to any such proceeding, but the very specialty of the work points to the propriety of those immediately benefited by it defraying its cost. The ordinary method of local assessment, therefore, would be just in principle —fortunately, it is easy of application. The total annual rental of Melbourne and the suburbs may, I believe, be taken at £1,250,000. A rate of 1s. in the pound would realise £62,500 per annum. Now, deducting from this sum £12,500 for expenses of maintenance, repairs, and other ordinary outlay, the remainder would discharge the principal sum with interest at 6 per cent. in rather less than eighteen years; after which, the cost of maintenance would not involve a rate of more than 2d. in the pound on the annual rental of the city and suburbs. I do not think that there would be any difficulty in raising the sum required on debentures, if issued by a properly constituted commission, more especially as they need not be placed on the market in a lump, but would probably occupy five or six years in the issue, such being the time that would be occupied in the construction of the works.

Thus far as to the cost of efficient drainage being beyond our means, and the estimate I have given admits of very considerable deductions, so far as actual outlay by the inhabitants is concerned. It is certain that cesspools when filled with *excreta* must be emptied, and the contents removed to a considerable distance. This involves expense which with

efficient sewage would never be incurred. Then, again, the constant repair rendered necessary by the defective condition of the house drains now in existence, would be avoided. The outlay upon these two items I should be fairly entitled to deduct from that which I have stated. It is, indeed, questionable whether, if we were to take a tolerably long period of time—say fifty years—the cost of efficient sewerage would not be actually less than the expense of the miserable shifts and expedients now in use. Nor would it be the least recommendation of the system, that in localities commercially valuable, dry cellarage would no longer be an impossibility. At the same time I may remind you that every week's delay will increase the difficulties and cost of a comprehensive plan. The few cases where powerful influence has secured from existing authorities permission to empty the sewage from large buildings directly into the Yarra—a permission, the legality of which, as well as the power of the City Council to interfere, is very questionable—if frequently repeated, will greatly interfere with it, and I trust that no further privilege of that kind will be granted, whoever may be the applicants.

I now come to the practicability of the scheme. I am aware that many scout a system of sewage as impossible. I remind them that the entire pollution of the area of ground on which our city stands is, as we are now proceeding, a mere question of time; and that long before it is complete, residence within its boundaries will also be an impossibility. This single circumstance should render us more anxious to inquire into the alleged impracticability of providing against it.

It will not, I presume, be denied, that as respects levels, the city is well situated. There is high ground, and there are low levels, into which the sewage could be carried; as in London there are the same, but more unfavorably situated.* We are not subject to those enormous fluctuations of the tide which have interfered so greatly with the outlet of the London sewage; and, indeed, I am not prepared to say, that our outfall need be such as to meet with any obstruction from such causes. Let it be supposed that the valley of the Yarra served as the line of the great trunk sewer, the lines running north and south being intercepted by those in the cross streets, which again were carried to the trunk, so as to avoid

* We have no acclivities more sudden than the slopes of which Holborn Hill, Skinner Street, and Ludgate Hill form parts.

any great aggregation of sullage in the lowest levels of Elizabeth and Swanston streets, and others similarly situated; there would always be a fall available in that, equal to that of the river itself. If the sewage were conveyed to a reservoir (commonly called a sumph) in a suitable position (say the bank of the Railway near the Saltwater River), so constructed as to be kept, as it were, hermetically closed, I do not know any reason why it might not be pumped to a height sufficient to admit of its being carried alongside the Melbourne and Geelong Railway to a point where its discharge into the waters of the Bay would be practically innocuous, or where it would be available for agricultural purposes. The pressure of the Yan Yean would furnish force enough to work the most powerful pump that could be required, and at very little expense.

I am not, of course, competent now to discuss the details of such a plan, nor could any one do so satisfactorily, whatever might be his professional acquirements, unless he had the necessary levels and other details before him. And, indeed, without such information, it is quite impossible to show that it would be impracticable, whatever assertions may be made to that effect. But if some efficient system of sewage is really required, it is time that the preliminary information be obtained. To effect this would, I apprehend, be within the scope of the Melbourne Sewage and Water Commission—the first half of their functions seem left in abeyance—to direct contour levels of the city and its vicinity to be taken, and to inquire whether any scheme, and what, would be most available for our wants.

Gentlemen, I have brought before you, in a general form, the conclusions arrived at after many years experience by the most eminent authorities in Great Britain, and the application of those conclusions to our own peculiar requirements is what we most stand in need of. It will be for the people, the parliament, and the government of the day to say how soon that application shall be made.

There remain three other considerations, to which, before closing this paper (already, I fear, too long), I must advert. The first is the manufacture of the necessary pipes. I am assured, on what I believe to be competent authority, that within a moderate distance of Melbourne there exists abundance of the finest material suitable for such a purpose. What we should require would be the importation of the simple machinery necessary, and of some skilled workmen to con-

duct the operations. In such a case, I apprehend that our own trade would derive a stimulus from the supply of our own requirements. We need not send one penny out of the country, except for the first machinery, workmen, and patterns. The second point is the employment of competent superintendents and laborers in the drainage itself. It is probable, that as respects everything but the laying and efficient junction of the pipes, the work would be such as any skilled engineer would be competent to conduct; but in the detailed manipulation it appears to me that a few foremen would be indispensable. They would know what we have yet to learn. I therefore beg to suggest that it would be advisable for the presiding authorities to open a communication with the London Board of Health on this point. It might further be judicious to supply that body with maps and contour levels of the district, as well as with such other particulars as would enable them to assist us with practical suggestions on the great work we have to carry out. The last point is the process of deodorization, and on this I have purposely kept silence, feeling that our principal object should be first to get *rid* of the sewage, letting the turning it to useful purpose be an after consideration, and fearing that its discussion might detract attention from what I consider the main question.

Viewed simply as a question of chemical science, there cannot be a doubt but that the most foul and fœtid sewage can be deodorized, but it is equally certain that, commercially, it has been a decided failure.

In proof of this I would beg leave to cite two authorities: The first, a writer in a late number of the *Times*, who makes the assertion that the reducing of sewage of towns to a solid, so as to be easy of carriage and useful as a manure, has never yet been profitably done. He further states that recent experiments tried on newly ploughed land, by allowing the liquid sewage to flow freely over it, have verified two facts:—1st. That land receives more benefit from the manure in the liquid than in the solid form; and 2nd.—That fallow land, particularly if of a loamy or sandy character, is the best and cheapest deodorizing agent known.

The second authority I shall cite is Professor Dugald Campbell, who says, in a Report on the application of Sewage to Agriculture, laid before the Chemical Society— "That manure had been prepared from sewage by simple filtration, but with an extremely imperfect removal of fertilizing matter;

also, by chemical precipitation, more especially by means of lime, as at Leicester. Sewage depends almost entirely on human excreta for its value as a manure. Now, while the total amount of dried excreta per head per diem is only two ounces, the average supply of water per head per diem amounts in London to thirty gallons, and that exclusive of rainfall. The problem consequently is, how to extract the two ounces of solid from the thirty or forty gallons of liquid. This problem is as yet unsolved, for the lime process fails to remove any large proportion of the nitrogeneous constituents of sewage, and the resultent manure is not sufficiently valuable to repay the cost of carriage to any great distance. The results of the employment of sewage water for irrigation, either on grass or fallow land, are altogether more satisfactory than those in which a solid sewage manure has been used."

At any rate, from this it would appear that it is questionable whether, if the agriculturists desired to use the sewage on the lowlands in the Werribee plains, it would not be more useful in its liquid form than any other.

In excuse for the extent to which I have trespassed upon your time in the consideration of this subject, I beg to say that I have done so from a conviction of its importance, and of the existing necessity for some decided and immediate steps in the matter. In doing so, I have purposely avoided going at length into technicalities, which, besides confusing the discussion, would have been interesting only to engineers. I have also, for the sake of condensation, omitted the diagrams and formulæ which might have confirmed, and, in some cases, illustrated the reasoning. But I hope sufficient has been said to awaken the attention of this Society to the position in which our city stands with reference to the most essential provision for the health, comfort, and morality of its inhabitants.

Gentlemen,—I am no advocate for undue Government interference in works of a local character, but yet I fully believe that the countenance of the Government to a well-digested scheme of this nature would materially facilitate its realisation. It is a question of a most vital character to the community, one in which the Government has already tacitly admitted an interest by the very title of the Sewage and Water Commission, and one the fostering of which would reflect credit upon any Government carried on for the welfare of the people.